Household Relief Programs: a Macroeconomic Analysis*

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Abstract

We analyze the effects at government interventions which aim to support households during challenging macroeconomic episodes. Using a multi-sector heterogeneous-agents model with non-homothetic preferences, we evaluate the welfare effects of fiscal support payments –possibly targeted to certain groups of households– vis-á-vis price controls. We provide a decomposition of the social welfare effects of these policies, revealing the importance of the underlying micro- and macroeconomic channels.

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1 Introduction

During the last two decades, households have lived through challenging macroeconomic circumstances. Specifically, the Great Recession and the Covid-19 pandemic, put household budgets under stress. The recent inflationary episode created a widespread increase in the cost of living, especially when price increases were concentrated in necessity sectors. In response to these events, many governments have intervened in order to support households. Some governments made large direct transfers to household, sometimes conditional on certain characteristics such as age or other demographic factors. Governments have also resorted to direct price controls, for instance by placing a cap on the the energy prices set by utilities companies.

The efficacy desirability of these programs is still debated. Some economists have warned that price controls distort household decisions, preventing a decline of e.g. energy consumption when the cost of energy increases. Indeed, it may be argued that it might be less distortionary to provide direct relief payments to certain households. On the other hand, it may be difficult to accurately target those households most in need and some economists have warned that large-scale, blanket fiscal support payments could themselves be inflationary.

The aim of this paper is to compare the welfare effects of different government policies in response to negative macro-economic or sector-level shocks. In order to take into account both the micro- and macro-economic channels, we use a quantitative Heterogeneous-Agents New-Keynesian model with non-homothetic preferences, which we can link directly to micro data on income, wealth and expenditure baskets. In this setting, we derive a social welfare function. In order to shed light on the trade-offs associated with different policies, we then provide a decomposition of this social welfare function. We then provide a quantitative evaluation. Because the model can be linked directly linked to micro data, we can evaluate not only lump-sum fiscal payments to all households, but also policies to targeted to groups with certain characteristics (observed in the micro data). For instance, we can consider policies targeted towards the elderly, or families.

Preliminary quantitative analysis suggests the following main policy trade-offs. On the one hand, lump-sum payments households have limited direct effects on aggregate inflation and the real economy, and create little sectoral misallocation. On the other hand, financing these payments with distortionary labor income taxes creates a distortion in the labor market. Moreover, since in the data there is a high degree of heterogeneity wealth, income and consumption baskets, even conditional on demographic characteristics, it may be difficult to target the cost-of-living payments, reducing the efficacy of this instrument.

Price controls, on the other hand, do create direct sectoral misallocation of consumption, and also contribute to price stickiness, distorting upward output following negative shocks. Thus, price controls tend to create both aggregate and sector-level distortions. On the positive side, however, price controls naturally benefits most those who are most affected by the shocks, making the policy naturally well-targeted. Which of the two policies (if any) is most beneficial to welfare, therefore generally depends on the specific sectoral nature of the shock.

2 The model

The model environment builds closely on Olivi et al. (2023), who study monetary policy. Here, we extend the fiscal side of the model and introduce price controls and cost-of-living payments.

2.1 Environment

Households. There is a continuum of heterogeneous households, of unit mass and indexed by i. In every period t, a household dies with a probability $\delta \in (0,1)$. Households consume goods from different sectors, indexed by $k = 1, 2.., K$. Within each sector, there is a unit mass continuum of differentiated varieties, indexed by j. The expected utility of household i at time t is given by:

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta(1-\delta))^{t+s} \left(u_i(\mathbf{c}_{t+s}(i)) - \chi \left(\frac{n_{t+s}(i)}{\vartheta(i)} \right) \right), \tag{1}$$

where $n_{t+s}(i)$ is effective labor supply, $\vartheta(i)$ is labor productivity, $\beta \in (0,1)$ is the subjective discount factor, and $\mathbb{E}_t$ is the conditional expectations operator. Moreover, the utility from consumption depends on a vector $\mathbf{c}_t(i) = \{\mathbf{c}_{1,t}(i), .., \mathbf{c}_{K,t}(i)\}$, where $\mathbf{c}_{k,t}(i)$ is a vector consisting of consumption of each variety j in sector k. Specifically, the flow utility from consumption is given by:

$$u_i(\mathbf{c}_t(i)) = U_i(\mathcal{U}(\mathbf{c}_{1,t}(i)), ..., \mathcal{U}(\mathbf{c}_{K,t}(i))),$$

where $U_i(\cdot)$ is an outer utility function, defined over sectoral bundles, which may be household specific. We assume that $U_i(\cdot)$ is differentiable and weakly separable across sectors. The sectoral bundles are in turn given by $\mathcal{U}(\mathbf{c}_{k,t}(i))$. We further assume that the inner utility function $\mathcal{U}(\cdot)$ is a concave, C^3-function which is symmetric over varieties. Moreover, $\chi(\cdot)$ is an increasing, twice differentiable function capturing disutility from labor supply.

Households can save in one-period nominal bonds, denoted by $b_t(i)$ and they are born with different initial levels of nominal wealth. Households also differ in terms of their labor productivity, $\vartheta(i)$, which is constant over time. We thus abstract from idiosyncratic risk, aside from mortality risk. We do allow for the possibility that some households are Hand-to-Mouth (HtM) consumers, which we treat as a permanent characteristic.[1] HtM households cannot adjust their bond holdings, and thus consume their current incomes. Households who are not HtM can choose bond holdings freely, facing only a natural borrowing limit. Households further differ in their ownership of firms.

The budget constraint of household i in period t is given by:

$$e_t(i) + \frac{b_{t+1}(i)}{R_t} = b_t(i) + n_t(i)(1-\tau_{w,t})W_t + \sum_k \varsigma_k(i) Div_{k,t} + T_t(i). \tag{2}$$

[1] Even without HtM households, distributional dynamics will generally matter for aggregates, due to the non-linearities embedded in the generalised, non-homothetic and non-CES preferences.

Table 1. Steady-state statistics

	Individual	Aggregate
Marginal Propensity to Consume:	$MPC(i) = \frac{\partial e_t(i)}{\partial b_t(i)}$	
Budget share:	$s_k(i) = \frac{e_k(i)}{e(i)}$	$\bar{s}_k = \frac{E_k}{E}$
Marginal budget share:	$\partial_e e_k(i) = \frac{\partial e_k(i)}{\partial e(i)}$	$\overline{\partial_e e_k} = \int \frac{e(i)}{E} \partial_e e_k(i) di$
Cross-price elasticity:	$\rho_{k,l}(i) = \frac{\partial c_k(i)}{\partial P_l} \frac{P_l}{c_k(i)}$	$\bar{\rho}_{k,l} = \frac{\partial C_k}{\partial P_l} \frac{P_l}{C_k}$
Demand elasticity:	$\epsilon_k(i) = -\frac{\partial c_k(i,j)}{\partial p_k(j)} \frac{p_k(j)}{c_k(i,j)}$	$\bar{\epsilon}_k = \int \frac{e_k(i)}{E_k} \epsilon_k(i) di$
Super-elasticity:	$\epsilon_k^s(i) = \frac{\partial \epsilon_k(i)}{\partial p_k(j)} \frac{p_k(j)}{\epsilon_k(i)}$	$\bar{\epsilon}_k^s = \frac{\partial \bar{\epsilon}_k}{\partial p_k(j)} \frac{p_k(j)}{\bar{\epsilon}_k}$
Markup sensitivity w.r.t. expenditures:	$\gamma_{e,k}(i) = \frac{\partial \mu_k}{\partial e_k(i)} \frac{E_k}{\mu_k}$	
Markup sensitivity w.r.t. wealth:	$\gamma_{b,k}(i) = \frac{\partial \mu_{k,t}}{\partial b_t(i)} \frac{E}{\mu_k}$	

Note: all statistics are evaluated in the deterministic steady state with zero inflation. $E_k = \int e_k(i)$ are aggregate expenditures on sector k and $E = \sum_k E_k$ are total expenditures across all sectors. Moreover, $C_k = E_k/P_k$ is aggregate sectoral consumption. Finally, $\rho_{k,l}(i)$ is a compensated elasticity.

Here, $e_t(i) = \sum_{k=1}^K e_{k,t}(i) = \sum_{k=1}^K \int_0^1 p_{k,t}(j) c_{k,t}(i,j) dj$ denotes the household's total consumption expenditures, R_t is the gross nominal interest rate on bonds, which is set by a central bank, W_t is the nominal wage per effective unit of labor, $\tau_{w,t}$ is a labor income tax rate, $Div_{k,t}$ are total dividends from sector k and $\varsigma_k(i)$ is the equity share of household i in firms in sector k. We assume that equity portfolios are perfectly diversified.

Finally, $T_t(i)$ is a government transfer to the household, which may depend on the household's characteristics such as age, family status, or region. We will evaluate different transfer programs.

In any period t, household i chooses consumption of each goods variety, $c_{k,t}(i,j)$, bond holdings, $b_t(i)$, and effective labor supply, $n_t(i)$, to maximize utility objective (1), subject to the budget constraint (2) and the laws of motion of equilibrium objects exogenous to households. HtM households in addition face the constraint $b_t(i) = b_{t-1}(i)$.

Some key statistics. In the absence of a parametric form for preferences, let us introduce some key concepts regarding household behavior. As discussed in Appendix **??**, we can express the demand of household i for a certain goods variety as a function of its price, $p_{k,t}(j)$, a vector of all other prices in the sector, denoted $\mathbf{p}_{k,t}$, and the total expenditures of the household on sector-k goods, $e_{k,t}(i)$. We denote this demand function by $c_{k,t}(i,j) = d_k\left(p_{k,t}(j), \mathbf{p}_{k,t}, e_{k,t}(i)\right)$.

We can now define a number of household-level statistics, evaluated at the deterministic steady state of the model, which we indicate by omitting the time subscript. We consider a steady state with zero inflation and therefore equal prices within sectors, i.e. $p_k(j) = P_k$ for any variety j in sector k where P_k is the sectoral price level. Note that in such a steady state it holds that $c_k(i,j) = c_k(i)$. Table 1 defines the statistics, which may all vary across households. The table also presents a number of aggregate counterparts that will play a role in the dynamic model.

The first statistic is the Marginal Propensity to Consume, often emphasized in the heterogeneous-agents literature. In our setting, we can derive $MPC(i) = \frac{R-1}{R} / \left(1 + \frac{Wn(i)\psi}{e(i)\sigma}\right)$ for non-HtM households and $MPC(i) = 1/\left(1 + \frac{Wn(i)\psi}{e(i)\sigma}\right)$ for HtM households. Within both groups of households, there is MPC heterogeneity resulting from differences in the wealth effect on labor supply, which in turn is due to differences in the composition of financial versus human wealth.

The next three statistics in the table derive from the outer utility function $U_i(\cdot)$ and thus pertain to the allocation of household expenditures across sectors. First, $s_k(i)$, is the regular budget share, i.e. the fraction of expenditures that household i devotes to sector k. Its aggregate counterpart, $\bar{s}_k$, is used to construct the Consumer Price Index, which is defined as $P_{cpi} = \sum_k \bar{s}_k P_k$. Second, $\partial_e e_k(i)$, is the household's *marginal* budget share on sector k. It measures the fraction of each marginal unit of expenditures that the household devotes to goods in sector k. This statistic is not much emphasized in the heterogeneous-agents literature. Indeed, under homothetic preference we obtain $\partial_e e_k(i) = s_k(i)$. However, in our model preference are non-homothetic the gap between the two statistics will play an important role. The aggregate (expenditure-weighted) counterpart of the marginal budget share is $\overline{\partial_e e_k}$. At the margin, households tend to spend less on necessity goods than they do on average, whereas the opposite is true for luxuries. Accordingly, we label k a necessity sector if $\overline{\partial_e e_k} < \bar{s}_k$, and a luxury sector if $\overline{\partial_e e_k} > \bar{s}_k$.

For later use, we define the *Marginal CPI* (MCPI) index as $P_{mcpi} = \sum_k \overline{\partial_e e_k} P_k$. This price index weighs sectors by their marginal rather than their regular budget shares. Relative to the CPI, the MCPI thus overweights luxury sectors and underweights necessity sectors.[2] Note that under homothetic preferences over sectors, marginal and regular budget shares coincide, so that the CPI and MCPI become equal. The final statistic relating to the outer utility function is $\rho_{k,l}(i)$, the compensated elasticity of consumption by household i of sector-k goods with respect to a change in P_l, the price of sector-l goods. Moreover, $\bar{\rho}_{k,l}$ is the aggregate counterpart.

The remaining statistics pertain to the inner utility $\mathcal{U}$, which defines utility over varieties within a sector. These statistics will be key determinants of markups in the model. The first, $\epsilon_k(i)$, is the elasticity of demand for a variety with respect to its price $p_k(j)$. Note that this elasticity varies not only across sectors, but also across households. When setting the markup, firms consider the aggregate demand elasticity for their good, $\bar{\epsilon}_k$, which weighs individual markups by expenditure shares. The steady-state markup is given by $\mu_k = \frac{\bar{\epsilon}_k}{\bar{\epsilon}_k - 1}$. While $\epsilon_k(i)$ denotes the demand elasticity at the steady state, the distribution of demand elasticities moves around over time: as households change their levels of expenditures, their demand elasticities change. The response of the individual demand elasticity to a change in the price is given by the price super-elasticity of demand, denoted by $\epsilon^s_k(i)$, as defined in the table.[3] Under CES preferences, demand elasticities are constant and hence $\epsilon^s_k(i) = 0$, but once moving beyond CES this is no longer the

[2] One may think of "Core CPI" –a popular index in practice– as an extreme sibling of the MCPI, in the sense that it completely disregards prices in two of the most important necessity sectors: food and energy.

[3] Note that, due to symmetry and anticipating that in the steady state firms are identical within sectors, $\epsilon_k(i)$ and $\epsilon^s_k(i)$ do not depend on j, i.e. at the steady state these elasticities are the same for all varieties within a sector.

case. The super-elasticity of *aggregate* demand for sector-k varieties can be expressed as $\bar{\epsilon}^s_k = (\int \epsilon^s_k(i)\epsilon_k(i)\frac{e_k(i)}{E_k}di - \int (\epsilon_k(i) - \bar{\epsilon}_k)^2 \frac{e_k(i)}{E_k}di)/\bar{\epsilon}_k$. This object takes into account that a change in prices not only affects $\bar{\epsilon}_k$ via changes in individual demand (the first term) elasticities, but also through changes in the composition of demand (the second term).

When moving beyond CES preferences, different households thus contribute differently to markups, depending on their price elasticities of demand, their super-elasticities, and their share in aggregate expenditures. We define two additional statistics which capture the combined effects of this. First, $\gamma_{e,k}(i)$ measures the sensitivity of the markup with respect to individual i's expenditures on sector-k goods: $\gamma_{e,k}(i) = \left(1 - \frac{\epsilon_k(i)}{\bar{\epsilon}_k}\left(1 + \frac{\partial \epsilon_k(i)}{\partial e_k(i)}\frac{e_k(i)}{\epsilon_k(i)}\right)\right)\frac{1}{\bar{\epsilon}_k - 1}$. Intuitively, if there is a relative increase in expenditures among households who have relatively low demand elasticities, the aggregate demand elasticity decreases, pushing up markups. A similar effect takes place if there is a shift in expenditures towards households whose price elasticity of demand is relatively insensitive to the level of expenditures. The second, $\gamma_{b,k}(i)$, captures the markup sensitivity with respect to individual wealth, which we can express as $\gamma_{b,k}(i) = MPC(i)\gamma_{e,k}(i)\partial_e e_l(i)/\bar{s}_k$. Note that under CES preferences we obtain $\gamma_{e,k}(i) = \gamma_{b,k}(i) = 0$.

Finally, we assume that the Elasticity of Intertemporal Substitution (EIS) and the Frisch elasticity of labor supply are homogeneous across households, and denote them by σ and ψ respectively. It is possible to allow for heterogeneity in these objects as well, at the expense of somewhat more complicated algebraic expressions.

Firms. Firms are monopolistically competitive, each producing a single goods variety j in a certain sector k. Within each sector, firms are ex-ante identical but subject to a Calvo-style pricing rigidity: they are able to adjust their price only with a probability $1 - \theta_k$ in every period. This probability may vary across sectors. Firms in sector k operate the following technology:

$$y_{k,t}(j) = A_{k,t}F_k(n_{k,t}(j), \tilde{Y}_{1,k,t}(j), \tilde{Y}_{2,k,t}(j), ..., \tilde{Y}_{K,k,t}(j)), \tag{3}$$

where $y_{k,t}(j)$ is output, $F_k(\cdot)$ is a sector-specific production function with constant returns to scale and $A_{k,t}$ is an exogenous, sector-specific productivity variable. In the production function, $n_{k,t}(j)$ are effective units of labor hired by the firm, while $\tilde{Y}_{l,k,t}(j)$ is the quantity of intermediate inputs from sector $l = 1, 2, ..., K$ used in production by firm j in sector k. Intermediate goods are produced by competitive firms who bundle varieties and sell on the these bundles. The technology of these firms is given by $\tilde{Y}_{k,t} = \tilde{F}_k(\tilde{\mathbf{y}}_{k,t})$ where $\tilde{\mathbf{y}}_{k,t}$ is a vector of varieties used in production and where we assume that $\tilde{F}_k$ is twice differentiable, symmetric across varieties and has constant return to scale. We can express the demand of the intermediate goods producers for an individual variety j as $\tilde{y}_{k,t}(j) = \tilde{d}_k\left(p_{k,t}(j), \mathbf{p}_{k,t}\right)\tilde{Y}_{k,t}$.

Firms take as given the aggregate of household demand functions, as well as demand by intermediate goods producers. The total demand for a variety is given by:

$$y_{k,t}(j) = \int_0^1 d_k\left(p_{k,t}(j), \mathbf{p}_{k,t}, e_{k,t}(i)\right)di + \tilde{d}_k\left(p_{k,t}(j), \mathbf{p}_{k,t},\right)\tilde{Y}_{k,t}. \tag{4}$$

where the first term corresponds to household demand and the second to demand from intermediate goods producers. Under CES preferences, household demand for a variety can be expressed as simple function of its relative price and total demand. In our more general setting, however, the composition of demand matters as well, as demand elasticities and super-elasticities vary across households.

Firms which are allowed to adjust their price do so to maximize the expected present value of profits. The decision problem of those firms is given by:

$$\max_{\substack{\{p_{k,t}(j),n_{k,t}(j),\\ y_{k,t}(j),\tilde{Y}_{l,k,t}\}}} \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda_{t,t+s}\theta_k^s (p_{k,t+s}(j) \left(y_{k,t+s}(j) - (1-\tau_k)(W_{t+s}n_{k,t+s}(j) + \sum_l P_{l,t+s}\tilde{Y}_{l,k,t+s}(j)) - T_{k,t+s} \right), \tag{5}$$

subject to Equations (3) and (4), where $\Lambda_{t,t+s}$ is the firm's stochastic discount factor.[4] In the above equation, τ_k is a time-invariant, sector-specific subsidy which may be used by the government to correct markup distortions in the steady state, and $T_{k,t}$ a lump-sum tax to finance the subsidy (which can be arbitrarily differentiated across sectors, as long as the government budget constraints is satisfied).

Monetary Policy. The nominal interest rate R_t is set by the monetary authority, taking fiscal policy as given, following a simple rule of the form $\frac{R_t}{R} = \left(\frac{1+\pi_{cpi,t}}{1+\pi_{cpi}}\right)^{\phi}$, where the central bank targets zero inflation in the steady state.

Government budget. For now, we assume that the fiscal authority runs a balanced budget, which implies:

$$\sum_k \tau_k \int_0^1 W_t n_{k,t}(j)dj + \tau_{w,t}\int_0^1 W_t n_k(i)di + \sum_l P_{l,t}\tilde{Y}_{l,k,t}(j))dj - \sum_k T_{k,t} = 0. \tag{6}$$

Later, we also consider versions of the model with time-varying government debt.

Demographics and Market Clearing. In any period, a fraction δ of all households dies. We assume that each deceased household is replaced by a new household of the same type. A household's type is pinned down by its labor productivity, $\vartheta(i)$, firm ownership, $\varsigma_k(i)$, initial bond holdings, $b_0(i)$, preferences, U_i, and HtM status. Bond market clearing implies that the average wealth of households is zero, and hence the same is true for deceased and newborn households, due to i.i.d. death probabilities. Therefore, the wealth given to new households can always be financed and the net inheritance from all deceased households is zero. From now on, we will assume that firm ownership is proportional to labor productivity.

[4] We do not specify the details of the discount factor since we will linearize the model around a steady state with zero inflation, which implies that $\Lambda_{t,t+s}$ drops out of the equations.

Clearing in the labor market and the bond market requires, respectively:

$$\int_0^1 n_t(i)di = \sum_k \int_0^1 n_{k,t}(j)dj, \\ \int_0^1 b_t(i)di = 0. \tag{7}$$

Goods market clearing requires, for any goods variety:

$$\int_0^1 c_{k,t}(i,j)di + \tilde{y}_{k,t}(j) = y_{k,t}(j). \tag{8}$$

and in every sector:

$$\tilde{Y}_{k,t} = \sum_l \int \tilde{Y}_{l,k,t}(j)dj. \tag{9}$$

An equilibrium is a law of motion for prices and allocations such that households, firms and the government behave as specified above, and markets clear.

It is worth noting that in the deterministic steady state of the model, households keep their bond holdings constant over time.[5] The model is thus consistent with any arbitrary steady-state distribution of wealth, which in the calibration we will take from the data.

2.2 Household relief programs.

Cost-of-living payments A first form or relief program we consider is lump-sum transfers to particular households. Since we assume a balanced government budget (for the moment), these transfers are financed by lump-sum taxes on other households.

Since we can link the model directly to the micro data, and since we observe a number of characteristics in the micro data, we can consider various targeted policies. In line with a recent policy in the United Kingdom, we will assume that the poorest 30 percent of all households receive a cost-of-living payment of Â£900, and that pensioners receive (potentially in addition) a payment of Â£300.

Price controls Another policy we consider is a price control, which have been imposed by governments. For instance, the UK government recently imposed a cap on energy prices.

We model price controls as a subsidy on a good, such that the price paid by the household is $\hat{Q}_{k,t} = (1 - t_k)\hat{P}_{k,t}$, specified in deviations from the steady state. This price subsidy is then financed by a lump-sum transfer on firms. [6]

[5] It can be shown that, in the absence of idiosyncratic income risk and aggregate shocks, the target level of wealth equals current wealth.

[6] To avoid the interaction with inner utility, we assume that households buy subvarieties full price and get a rebate on their average expense on product k.

2.3 Dynamic Equilibrium

In order to study dynamics, we linearize the model around a deterministic steady state. We assume that the central bank targets long-run price stability, so steady-state prices are identical within sectors. We further assume that the government eliminates steady-state markup distortions using the subsidy τ_k.

We now present the system of equations that jointly characterize the dynamic equilibrium of the model, to a first-order approximation. Appendix **??** provides the underlying derivations, and Appendix **??** summarizes the equations.

To ease the exposition, we present in the main text a simplified model version without HtM households and without Input-Output linkages. In the quantitative applications, we do include these features. Moreover, in Section 3 we will consider a version of the model that is further simplified and derive a number of analytical results which help to sharpen intuition.

New Keynesian Phillips Curve. The central equation in our analysis is the New Keynesian Phillips Curve (NKPC). Let $\hat{P}_{k,t} = \int \hat{p}_{k,t}(j)dj$ be the price of the sector-k goods, where hatted variables denote log deviations from the steady state and where we used that in the steady state prices are identical within sectors. We will denote steady-state variables by omitting the time subscript t. The steady-state interest rate equals $R = \frac{1}{\beta(1-\delta)}$. The net rate of inflation in sector k is given by:

$$\pi_{k,t} = \hat{P}_{k,t} - \hat{P}_{k,t-1}. \tag{10}$$

Moreover, individual consumption of sector-k goods is given by $\hat{c}_{k,t}(i) = \hat{e}_{k,t}(i) - \hat{P}_{k,t}$. The NKPC for sector k can be now expressed as:

$$\pi_{k,t} = \kappa_k \tilde{\mathcal{Y}}_t + \lambda_k \left(\mathcal{NH}_t + \mathcal{M}_{k,t} - \mathcal{P}_{k,t} \right) + \beta \mathbb{E}_t \pi_{k,t+1}, \tag{11}$$

with the following wedges:

$$\tilde{\mathcal{Y}}_t = \hat{\mathcal{Y}}_t - \hat{\mathcal{Y}}_t^*, \qquad \text{(Output gap)}$$

$$\mathcal{NH}_t = \sum_l (\overline{\partial_e e_l} - \bar{s}_l)(\hat{P}_{l,t} - \hat{P}_{l,t}^*), \qquad \text{(Non-homotheticity wedge)}$$

$$\mathcal{M}_{k,t} = \int \gamma_{e,k}(i) \frac{c_k(i)}{C_k} \hat{c}_{k,t}(i) di - \Gamma_k \tilde{\mathcal{Y}}_t, \qquad \text{(Endogenous markup wedge)}$$

$$\mathcal{P}_{k,t} = (\hat{P}_{k,t} - \hat{P}_{cpi,t}) - (\hat{P}_{k,t}^* - \hat{P}_{cpi,t}^*), \qquad \text{(Relative price wedge)}$$

and the following slope coefficients:

$$\kappa_k = \lambda_k \left(\frac{1}{\sigma} + \frac{1}{\psi}\right) \left(1 + \frac{\sigma\psi}{\sigma+\psi}\Gamma_k\right),$$
$$\lambda_k = \frac{(1-\theta_k)(1-\theta_k/R)}{\theta_k}\frac{\bar{\epsilon}_k - 1}{\bar{\epsilon}_k - 1 + \bar{\epsilon}_k^s},$$
$$\Gamma_k = \frac{R}{R-1}\frac{\sigma+\psi}{\sigma}\int \gamma_{b,k}(i)\frac{Wn(i)}{WN}di.$$

Before explaining our generalized NKPC in detail, let us note that it is a generalisation of the "standard" NKPC. As usual, the equation relates current sectoral rate of inflation, $\pi_{k,t}$, to the discounted expected rate of inflation, $\beta\mathbb{E}_t\pi_{k,t+1}$, and an "output gap", $\tilde{\mathcal{Y}}_t$.

In addition, a number of wedges emerge in the NKPC, which affect the joint dynamics of the output gap and inflation. The first of these, $\mathcal{NH}_t$, arises due to non-homothetic preferences over sectors, which makes the composition of consumption baskets vary across households and over time. The second, $\mathcal{M}_{k,t}$, arises due to changes in markups due to fluctuations in the price elasticities of demand faced by firms, which are no longer constant once one deviates from CES preferences. We label this wedge the *endogenous markup wedge*. The two new wedges will affect the trade-offs between output and inflation faced by the central bank. Finally, there is a relative price wedge $\mathcal{P}_{k,t}$ which generally arises in New Keynesian models with sectoral asymmetries.

Slope of the NKPC. Let us now discuss the equation in more detail, starting with κ_k, the slope coefficient with respect to the output gap. The first term within this coefficient, λ_k, captures the micro-level pass-through of marginal costs to prices and in turn consists of two components. The first component within λ_k, i.e. $\frac{(1-\theta_k)(1-\theta_k/R)}{\theta_k}$, is due to sticky prices and is standard in the NK model. The second component, $\frac{\bar{\epsilon}_k-1}{\bar{\epsilon}_k-1+\bar{\epsilon}_k^s}$, is due to the endogeneity of demand elasticities. Intuitively, a firm realises that if it raises its price, demand will fall and, as a result, consumers may become more price sensitive. This component does not appear under CES preferences ($\bar{\epsilon}_k^s = 0$), but it does appear under for instance Kimball preferences. In a typical calibration it holds that $\bar{\epsilon}_k^s > 0$, which implies that the pass-through from marginal costs to prices is less than one-for-one, even when prices are fully flexible.

The second term in the definition of κ_k, i.e. $\left(\frac{1}{\sigma} + \frac{1}{\psi}\right)$, is standard in the NK literature. The third term, $\left(1 + \frac{\sigma\psi}{\sigma+\psi}\Gamma_k\right)$, is again due to non-CES preferences. However, this time it captures a macro effect: when aggregate spending changes, demand elasticities react, which induces firms to change markups. When markups tend to be increasing in wealth ($\gamma_{b,k}(i) > 0$) then an increase in aggregate income makes consumers less price sensitive, therefore pushing up markups. Again, the term vanishes under CES preferences.[7]

[7] It also vanishes under Kimball preferences, since such preferences are homothetic, in the sense that they are scaled to be invariant to total demand.

Note further that in the general setting, κ_k depends on the entire steady-state distribution of expenditures, through Γ_k and $\bar{\epsilon}_k^s$. Thus, long-run changes in inequality affect the slope of the NKPC. As such, our environment differs from standard HANK settings, in the sense that inequality affects not only the 'demand block' of the model, as formed by consumption Euler equations and budget constraints, but also the 'supply block', as formed by the NKPCs.

Output gap. The term on the right hand side of the NKPC is the well-known "output gap". Here, $\hat{\mathcal{Y}}_t$ is an aggregate demand index, and $\hat{\mathcal{Y}}_t^*$ is "natural" counterpart, indicated by a star and defined as its level in a parallel economy without markup distortions. As in the standard NK model, the output gap captures distortions in the labor market due to time-varying markups. To see this concretely, one can express the output gap alternatively as a (household) wage gap: $\tilde{\mathcal{Y}}_t = \frac{\psi}{1+\frac{\psi}{\sigma}}\left(\hat{w}_{h,t} - \hat{w}_{h,t}^*\right)$, where $\hat{w}_{h,t} = \hat{W}_t - \sum_{l=1}^K \overline{\partial_e e_l}\hat{P}_{l,t}$ is the real wage, computed using the Marginal CPI (MCPI) index as the deflator, which is the relevant wage for marginal labor supply decisions. Moreover, $\hat{w}_{h,t}^* = \sum_{l=1}^K \overline{\partial_e e_l}\hat{A}_{l,t}$ is the natural counterpart of the real wage. This expression for the output gap also obtains in the standard NK model, in which the CPI and MCPI coincide. It can also be shown that the output gap as defined here appears distinctly in the function measuring the social welfare loss due to aggregate fluctuations.

Dynamically, the output gap index evolves according to the following Euler equation:

$$\tilde{\mathcal{Y}}_t = \mathbb{E}_t\tilde{\mathcal{Y}}_{t+1} - \sigma\mathbb{E}_t\left(\hat{R}_t - \pi_{mcpi,t+1} - \hat{r}_t^*\right). \tag{12}$$

This Euler equation has the standard form, except that the real interest rate is computed using $\pi_{mcpi,t} = \sum_{l=1}^K \overline{\partial_e e_l}\pi_{l,t}$, i.e. MCPI rate of inflation, rather than the regular CPI. Intuitively, when households decide on consumption today versus consumption tomorrow, they consider on which sectors they spend at the margin. In the Euler equation, $\hat{r}_t^*$ is the natural real interest rate associated with the demand index, i.e. the real interest rate that satisfies the Euler Equation for the natural level of aggregate demand. We can express this rate as:

$$\hat{r}_t^* = \frac{1}{\sigma+\psi}\sum_{l=1}^K\left(\psi\overline{\partial_e e_l} + \bar{s}_l\right)(\hat{A}_{l,t+1} - \hat{A}_{l,t}), \tag{13}$$

Moreover, we can express as the natural level of demand and the natural sectoral price as $\hat{\mathcal{Y}}_t^* = \sum_{l=1}^K \frac{\psi\overline{\partial_e e_l}+\bar{s}_l}{1+\psi/\sigma}\hat{A}_{l,t}$ and $\hat{P}_{k,t}^* = -\hat{A}_{k,t}$, respectively.

Note that in the equation for the natural rate, both regular budget shares ($\bar{s}_l$) and the marginal budget shares ($\overline{\partial_e e_l}$) enter. Indeed, in this economy, both the regular CPI and the MCPI matter for aggregate demand. To clarify this point further, let us express the natural level of demand as $\hat{\mathcal{Y}}_t^* = -\frac{\psi}{1+\psi/\sigma}\hat{P}_{mcpi,t}^* - \frac{1}{1+\psi/\sigma}\hat{P}_{cpi,t}^*$, i.e. as a weighted sum of the natural CPI and MCPI. Intuitively, sectoral productivity shocks directly affect aggregate income by shifting the productive capacity of the economy. For this effect, the regular budget shares (i.e. CPI shares) are the relevant sectoral weights. Secondly, sectoral shocks have an indirect equilibrium effect on households' marginal saving and labor supply decisions. For these decisions, the marginal budget shares are the relevant sectoral weights since, when making such decisions, households consider which kind of goods they spend on at the margin.

Non-homotheticity wedge. We now discuss the two novel NKPC wedges. The first of these, $\mathcal{NH}_t = \sum_{l=1}^{K}(\overline{\partial_e e_l} - \bar{s}_l)(\hat{P}_{l,t} - \hat{P}^*_{l,t})$, is a wedge which arises due to non-homothetic preferences. This wedge increases when prices are distorted downward ($\hat{P}_{l,t} < \hat{P}^*_{l,t}$) in necessity sectors ($\overline{\partial_e e_l} < \bar{s}_l$), but falls when prices are distorted downward in luxury sectors. Indeed, the movements in this wedge will depend critically on the sectoral nature of shocks. Note that this wedge it is not indexed by k, since it derives from a distortion in the aggregate labor market. Note further that under homothetic preferences, marginal and regular budget shares coincide and hence $\mathcal{NH}_t = 0$. Under non-homothetic preferences, the wedge moves over time. The direction and magnitude of its movement depends on the gap $\overline{\partial_e e_l} - \bar{s}_l$, which in turn depends on the extent of steady-state inequality.[8]

To understand the wedge, it is important to realise that in an economy with non-homothetic preferences, labor supply optimally responds to changes in relative productivity, even if aggregate productivity (i.e. weighted sectoral productivity) does not change. Intuitively, when the relative productivity of luxury sectors increases, and relative prices in these sectors fall, households optimally increase labor supply since at the margin they spend relatively more on luxuries. To see this concretely, note that when CPI weighted aggregate productivity does not move, then $\hat{\mathcal{Y}}^*_t = -\frac{\psi}{1+\psi/\sigma}\hat{P}^*_{mcpi,t}$. Given this, any increase in the relative productivity of luxury sectors means that the natural MCPI declines, which leads to an increase in labor supply, increasing the natural level of output. However, when prices are sticky, the relative price movements are muted, and as a result $\mathcal{Y}_t$ increases by less than its natural counterpart, i.e. the output gap becomes negative.

For an alternative (but related) interpretation of the wedge, it is useful to consider an alternative formulation, given by $\mathcal{NH}_t = (\hat{w}_{f,t} - \hat{w}^*_{f,t}) - (\hat{w}_{h,t} - \hat{w}^*_{h,t})$. Here, $\hat{w}_{f,t} = \hat{W}_t - \hat{P}_{cpi,t}$ is the real wage according to the CPI, which is relevant to the marginal cost of the firm (weighted by sales), and $\hat{w}^*_{f,t} = \sum_{l=1}^{K}\bar{s}_l\hat{A}_{l,t}$ is its natural counterpart. Recall that $\hat{w}_{h,t} = \hat{W}_t - \sum_{l=1}^{K}\overline{\partial_e e_l}\hat{P}_{l,t}$ is the real wage according according to the MCPI deflator, which is relevant to households' marginal labor supply decisions, and $\hat{w}^*_{h,t} = \sum_{l=1}^{K}\overline{\partial_e e_l}\hat{A}_{l,t}$ is its natural counterpart. We now observe that $\mathcal{NH}_t$ can be interpreted as a term capturing the extent to which real wage distortions differ between households and firms. As such, $\mathcal{NH}_t$ can be interpreted as a labor wedge, akin to a labor income tax distortion.

Endogenous markup wedge. The second novel wedge, $\mathcal{M}_{k,t}$, captures the evolution of the distribution of price elasticities of demand for individual goods varieties, which affects the markups set by firms. The distribution of demand elasticities in turn fluctuates with the distribution of expenditures. The distributional origins of the wedge become clear by observing first term in its definition, $\int \gamma_{e,k}(i)\frac{c_k(i)}{C_k}\hat{c}_{k,t}(i)di$, which integrates over individual households. Here $\hat{c}_{k,t}(i)$ is the consumption change of household i, $\frac{c_k(i)}{C_k}$ is

[8] Under non-homothetic preferences, budget shares are non-linear functions total expenditures, hence a long-run change in inequality will generally change the gap between marginal and regular budget shares.

the household's share in total sectoral consumption, and $\gamma_{e,k}(i)$ captures the change in demand elasticity when individual expenditure change, and how this affects the markup. The second term, $-\Gamma_k \tilde{\mathcal{Y}}_t$, subtracts the endogenous markup response due to fluctuations in the output gap, as this effect has been subsumed in κ_k.

The endogenous markup wedge arises due to deviation from CES utility.[9] To see this, note that under CES preference we obtain $\gamma_{b,k}(i) = \Gamma_k = 0$, as demand elasticities are constant, which in turn implies that $\mathcal{M}_{k,t} = 0$. Moving beyond CES, the wedge takes the same form as exogenous markup shocks often considered in New Keynesian models. However, in our setting it is a rich endogenous object, which is shaped by the distribution of expenditures across households, and therefore moves along with the distribution of income and wealth. Nonetheless, it turns out that the evolution of the endogenous markup wedge can be represented in a tractable way. Specifically, it can be decomposed as:

$$\mathcal{M}_{k,t} = \Gamma_k \hat{\mathcal{Y}}_t^* + \mathcal{M}_{k,t}^P + \mathcal{M}_{k,t}^D. \tag{14}$$

The first component, $\Gamma_k \hat{\mathcal{Y}}_t^*$, is due to changes in demand elasticities in response to changes in the natural level of aggregate demand. Intuitively, during an economic downturn households cut expenditures and become more price-sensitive, which induces firms to reduce markups.

The second component captures how substitutions in response to changes in prices in other sectors affect demand elasticities:

$$\mathcal{M}_{k,t}^P = \sum_{l=1}^{K} \mathcal{S}_{k,l} \cdot \left(\hat{P}_{l,t} - \hat{P}_{k,t}\right), \tag{15}$$

where $\mathcal{S}_{k,l} = \int_i \frac{e_k(i)}{E_k} \gamma_{e,k}(i) \rho_{k,l}(i) di$ captures the effect of cross-price substitution on demand elasticities, and hence markups.

The third component, $\mathcal{M}_{k,t}^D$, summarizes the effects of changes in the distribution of household-level real expenditures on markups. For instance, a redistribution from poor to rich agents may give rise to an increase in markups, if rich people are more price sensitive. The evolution of $\mathcal{M}_{k,t}^D$ can be characterized by the following equation:

$$\mathcal{M}_{k,t}^D = \mathbb{E}_t \mathcal{M}_{k,t+1}^D - \sum_{l=1}^{K} \sigma_{k,l}^{\mathcal{M}} (\hat{R}_t - \mathbb{E}_t \pi_{l,t+1}) - \frac{\delta}{1-\delta} \mathbb{E}_t \mathcal{M}_{k,t+1}^0, \tag{16}$$

for any sector k, where $\sigma_{k,l}^{\mathcal{M}} = \sigma \int \gamma_{e,k}(i) \frac{e(i)}{E_k} \partial_e e_k(i) \partial_e e_l(i) di - \sigma \overline{\partial_e e_l} \Gamma_k$. In Equation (16), $\mathcal{M}_{k,t+1}^0$ captures the dynamics of the wealth distribution, insofar relevant for the markup

[9] Note that preferences may be homothetic but non-CES and vice versa.

wedge. It is pinned down by the following equation:

$$\mathcal{M}^0_{k,t} = \frac{1}{(1-\delta)\,R}\mathbb{E}_t\mathcal{M}^0_{k,t+1} + \int \gamma_{b,k}(i)\frac{b(i)}{RE}di\left(\hat{R}_t - \pi_{cpi,t+1}\right) \\ -\sum_{l=1}^{K}\int \gamma_{b,k}(i)\left(\frac{e(i)}{E}\left(s_l(i)-\bar{s}_l\right) + \frac{\psi Wn(i)}{WN}\left(\partial_e e_l(i) - \overline{\partial_e e_l}\right)\right)di\hat{P}_{l,t} - \frac{R-1}{R}\mathcal{M}^D_{k,t}. \tag{17}$$

Here, the second and the third term on the right-hand side capture, respectively, redistributions due to changes in real interest rates, and due to changes in sectoral prices, both of which have implications for markups when preferences are non-CES.

Relative price wedge. The final wedge in the NKPC, $\mathcal{P}_{k,t} = (\hat{P}_{k,t} - \hat{P}_{cpi,t}) - (\hat{P}^*_{k,t} - \hat{P}^*_{cpi,t})$ arises due to distortions in relative sectoral prices. Specifically, $\hat{P}_{k,t} - \hat{P}_{cpi,t}$ is the sectoral price, relative to the CPI and $\hat{P}^*_{k,t} - \hat{P}^*_{cpi,t}$ is its natural equivalent. The wedge $\mathcal{P}_{k,t}$ is generally present in multi-sector extensions of the standard NK model, if sectors are asymmetric in some way, e.g. if they differ in the degree of price rigidity or if there are sectoral shocks.

Monetary policy. In the positive part of our analysis, we will consider a simple interest rate rule of the following form:

$$\hat{R}_t = \sum_k \phi_k \pi_{k,t}, \tag{18}$$

where setting $\phi_k = \phi\bar{s}_k$ delivers a rule which responds to the CPI inflation rate. In section 6, we will move beyond the simple rule and instead consider the fully optimal Ramsey policy.

Dynamic Equilibrium. Equations (10)-(18) constitute a system of $5K+3$ equations in $5K+3$ endogenous variables, given by $\{\hat{P}_t, \pi_{k,t}, \mathcal{M}^D_{k,t}, \mathcal{M}^P_{k,t}, \mathcal{M}^0_{k,t}\}^K_{k=1}, \tilde{\mathcal{Y}}_t, \hat{R}_t, r^*_t$. We can thus characterize the model with a core block of equations, despite the fact that fluctuations in the distribution of income and wealth matter for the aggregate equilibrium outcomes. The equations for $\mathcal{M}^D_{k,t}$ and $\mathcal{M}^0_{k,t}$ keep track of the relevant distributional moments in a tractable way.

Distributional dynamics. While we do not need to keep track of the full distributional dynamics in order to solve for the aggregate equilibrium, it is straightforward to solve for such dynamics. Here, we focus on the distribution of consumption. Let us define the response of real consumption expenditures of household i as $\hat{c}_t(i) = \hat{e}_t(i) - \sum_{l=1}^K s_l(i)\widehat{P}_{l,t}$. Moreover, let $\boldsymbol{\omega}$ be a vector defining a weight $\omega(i)$ on each household i, with $\int \chi(i)di = 1$. We can thus use $\boldsymbol{\omega}$ to select and weight any arbitrary subset of households.

Now consider some moment of the consumption distribution, $\hat{C}_t(\boldsymbol{\omega}) = \int \omega(i)\hat{c}_t(i)di$. For instance, if we set $\omega(i) = e(i)/E$, then this moment corresponds to the aggregate response of real expenditures. We could also set $\omega(i) = 1$ for only one specific household i and zero for all others. In that case, $\hat{C}_t(\boldsymbol{\omega})$ corresponds to the individual consumption response of a particular household. Alternatively, one can choose $\boldsymbol{\omega}$ to compute the average response among households with certain characteristics. We can characterize $\hat{C}_t(\boldsymbol{\omega})$ with the following Euler equation:

$$\mathbb{E}_t\hat{C}_{t+1}(\boldsymbol{\omega}) - \hat{C}_t(\boldsymbol{\omega}) = \sigma\left(\int\omega(i)di\hat{R}_t - \sum_k\int\omega(i)\partial_e e_k(i)di\,\mathbb{E}_t\pi_{k,t+1}\right) + \frac{\delta}{1-\delta}\hat{C}^0_t(\boldsymbol{\omega}), \quad (19)$$

where wealth dynamics are captured by:

$$\hat{C}^0_t(\boldsymbol{\omega}) - \frac{1}{(1-\delta)R}\mathbb{E}_t\hat{C}^0_{t+1}(\boldsymbol{\omega}) = \int\omega^0(i)\frac{b(i)}{RE}di\left(\hat{R}_t - \mathbb{E}_t\sum_k\bar{s}_k\mathbb{E}_t\pi_{k,t+1}\right) + \left(1+\frac{\psi}{\sigma}\right)\int\omega^0(i)\frac{Wn(i)}{WN}di\hat{\mathcal{Y}}_t$$
$$-\sum_k\int\omega^0(i)\left(\frac{e(i)}{E}\left(s_k(i)-\bar{s}_k\right) + \frac{Wn(i)}{WN}\psi\left(\partial_e e_k(i) - \overline{\partial_e e_k}\right)\right)di\hat{P}_{k,t} - \frac{R-1}{R}\hat{C}_t(\boldsymbol{\omega}), \quad (20)$$

where we defined $\omega^0(i) = \frac{R-1}{R}\frac{\omega(i)}{e(i)/E + Wn(i)/WN\frac{\psi}{\sigma}}$.

3 Quantitative Results

In this section, we provide some preliminary quantitative results. We calibrate the model as in Olivi et al. (2023). We then consider a negative shock to the sector Electricity & Gas, leading to an increase in energy prices.

3.1 Cost-of-living payments

We first consider cost-of-living payments, in response to the energy shock. Mimicking a recent UK policy, we assume that the poorest 30 percent of households receive a lump-sum cost-of living payment of Â£900, whereas retired households receive Â£300. We consider in turn the effects at the macro, sectoral, and micro levels.

macro effects Figure 1 shows the effects of the energy shock on the aggregate output gap and CPI inflation, with and without the cost-of-living payments. The cost-of-living payments push up slightly the response of both variables. Intuitively, recipients of the transfers have relatively high Marginal Propensities to Consume (MPC's). Therefore, the redistribution increases aggregate demand. Quantitatively, however the effects are small, since MPCs are not very highly correlated with income and age.

sectoral effects Figure 2 shows the effect of the policy on energy consumption, which is very minimal. This is perhaps unsurprising, since the policy is a redistributive one which does not directly affect the price of energy.

micro effects Figure 3 shows the effects of the transfer policy on the distribution of consumption. As expected, the policy benefits the poorest households. However, the largest negative effects are on households with moderate incomes, who are just ineligible for the payments, but do pay for them through taxes.

3.2 Price controls

Next, we consider a control of prices of Electricity and Gas, such that households are fully insulated from the increase in prices in this sector following the shock, i.e. energy prices are fully capped.

macro effects Figure 4 shows the effects of the energy price cap on the aggregate output gap and inflation. The policy pushes up the output gap response considerably. Intuitively, by preventing price increases the policy stimulates aggregate demand. At the same time, the policy does (mechanically) reduce inflation rates faced by households. However, once we exclude the mechanical effect of the cap (yellow line), the inflation response is not much affected, compared to the simulation without price control.

sectoral effects Figure 3 shows the effect of price cap policy on energy consumption. Unsurprisingly, the policy increases energy consumption, suggesting that it creates considerable sectoral misallocation of consumption.

micro effects Finally, Figure 4 shows the effect of the price cap on the distribution of consumption. In the left panel, the horizontal axis denotes steady-state income. While the policy on average benefits poor people, there is a large degree of heterogeneity conditional income. This is the case since, in the data, there is a lot of heterogeneity of energy expenditure shares, even conditioning on income.

The right panel of Figure 4 instead has the energy share on the horizontal axis. Now we observe a much stronger correlation: those households with the highest expenditure shares tend to benefit most from the policy, though still there is considerable heterogeneity conditional on expenditure shares, since households vary in other dimensions too. Overall, however, it appears that the policy is relatively well targeted.

4 Conclusion

This paper studies the effects of household relief programs, in particular cost-of-living payments and price controls. We consider the macro effects, micro effects and sectoral effects. The next step is to compute welfare effects at the micro level.

Our findings so far suggest the following policy trade-off: on the one hand, lump-sum cost-of-living payments generate relatively small macro-economic and sector-level distortions. On the other hand, they may not be particularly well targeted since in the data there is a lot of heterogeneity in budget shares, even after conditioning on household characteristics.

Price controls, on the other hand, create larger macro- and sector-level distortions, but are naturally targeted towards towards those households who are most affected by sectoral inflation.

While many economist are generally sceptical of price control (except for the nominal inter-temporal price, i.e. the interest rate, which is controlled central bank policy), our initial exploration suggests that trade-offs may be more nuanced, and that the appropriate policy instrument may depend on the precise nature of the shock, for instance its sectoral origin.

References

Olivi, Alan, Vincent Sterk, and Dajana Xhani (2023) "Optimal Monetary Policy during a Cost-of-Living Crisis," Working paper.

Figures

Figure 1. Cost-of-Living Payments: macro effects

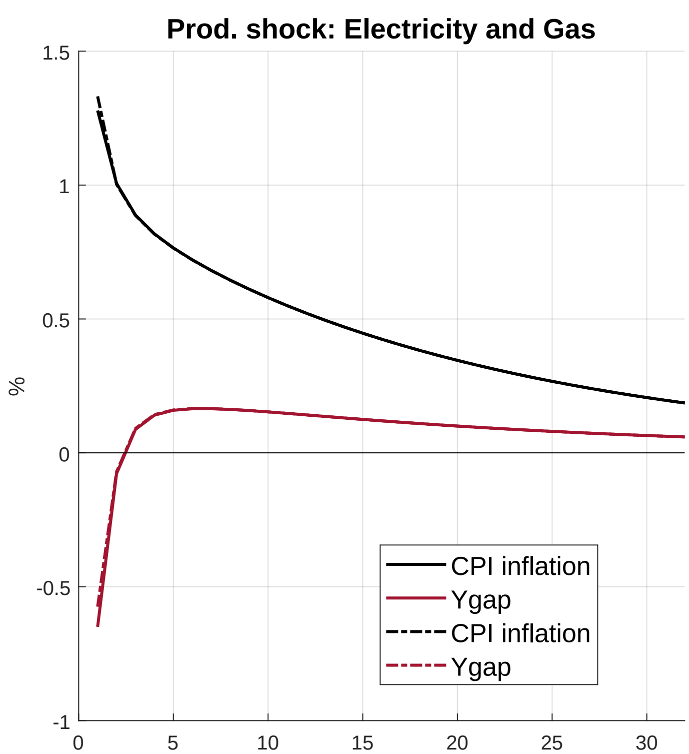

Figure 2. Sectoral effect: response of energy consumption

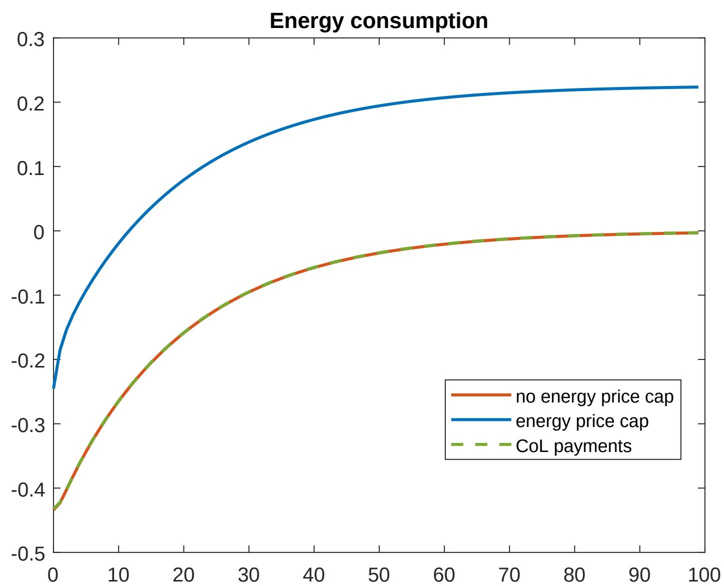

Figure 3. Cost-of-Living Payments: micro effects

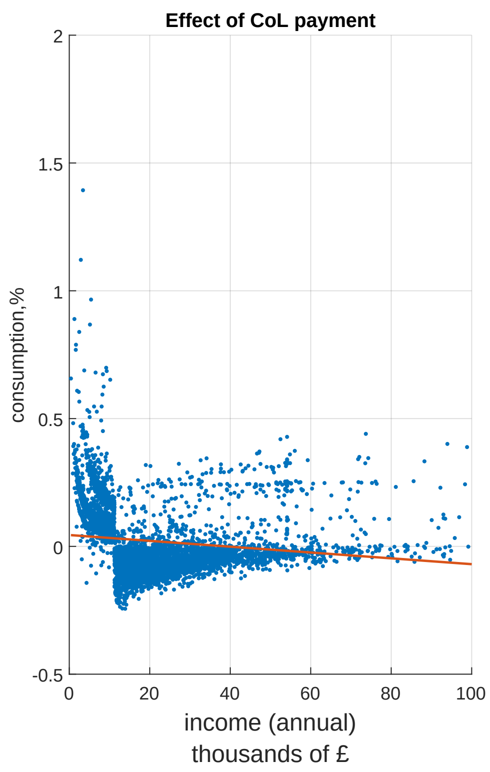

Figure 4. Energy price cap: macro effects

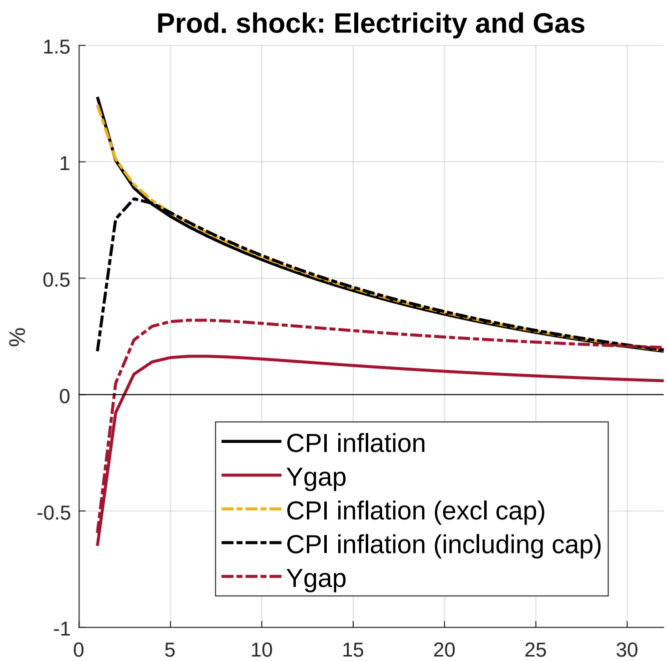

Figure 5. Energy price cap: micro effects